Magnetic Induction in a Slinky

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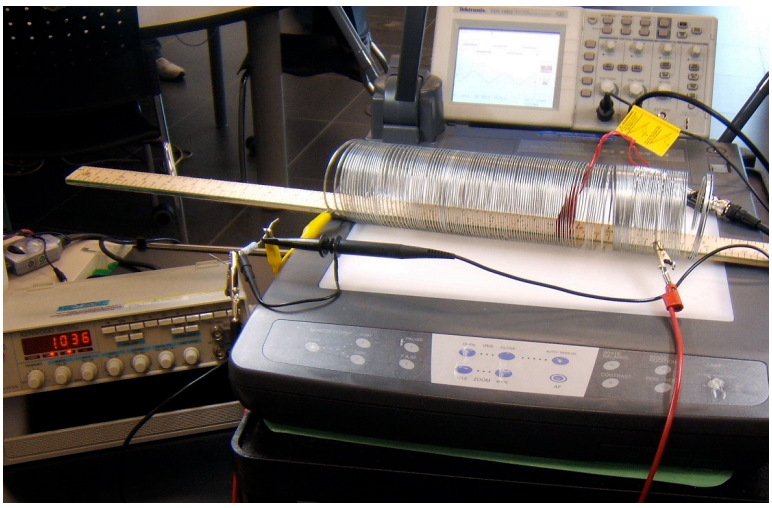
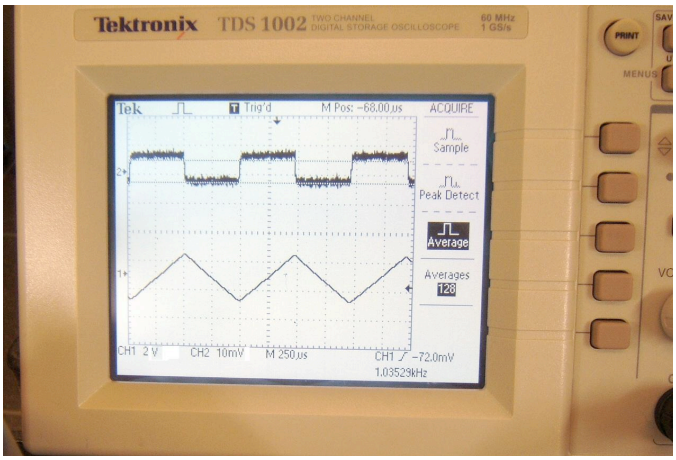


I managed to set up the complete apparatus on the AV stand so that the Elmo could display the apparatus on the projectors.. The oscilloscope is perched (precariously) on the back of the stand so that the camera could be tilted to display the oscilloscope screen to the class. The pick-up coil is inside the slinky.

Data:

Loop density of slinky $n = 440$ turns/m
radius of pickup coil, $r = 37 \pm 3$ mm (±8%)
area of pickup coil, $A_p = 1.08 \times 10^{-3} m^2$ (±16%) (keeping the loops on a form would reduce the error).
Peak-to-peak voltage across 10Ω resistor: $\Delta V = 3.28 \pm 0.05$ V
Amplitude of pick-up signal: 4,0±0.4 mV



Calculations:

$\Delta B = \mu_0 n \Delta I = \mu_0 n \Delta V / R$
$= (4\pi \times 10^{-7})(440)(3.28/10) = 1.81 \times 10^{-4}$ T (±10%)

$\Delta t = 1/2f = 0.450\ \mu s$
$\Delta B/\Delta t = (1.81 \times 10^{-4}\ T)/450\mu s = 4.02 \times 10^{-4}$ T/s (±10%)
$\mathscr{E} = N_p A_p \Delta B/\Delta t = (10)(1.08 \times 10^{-3})(4.02 \times 10^{-4}\ W/s)$
$= 4.34$ mV (±20%)

Thus the predicted EMF in the pick-up coil is within error bars of the measured value: 4.0 mV.

Common issues:

- getting the input attenuation wrong: e.g., x1 instead of x10 or vice versa
- measuring the diameter of the pickup coil and using it as the radius
- measuring peak-to-peak voltage on the pick-up coil instead of using cursors to measure 0 to $<V_{max}>$ (this contains two issues, the peak is much higher than the average and we need the voltage with respect to zero, not V_{min}.)

Induction in the field coil

Set up as described in Activity Guide except used a 10Ω resistor to monitor current.

Data

radius of field coil: $R_f = 7.25$ cm
area of field coil $A_f = 1.26 \times 10^{-3}$ m^2
peak-to-peak current in the field coil: $\Delta I = 0.35$ A (I used a 10Ω resistor instead 1 kΩ)
$\Delta t = 1/200$ s ($f = 100$ Hz)
number of loops in field coil: $N_f = 200$
number of loops in the pick-up coil: $N_p = 1100$
radius of pickup coil, $r = 40 \pm 2$ mm (±5%)
area of pickup coil, $A_p = 1.26 \times 10^{-3}$m^2

Calculation

$\Delta B = N \mu_0 \Delta I / 2R_f = 200\ (4\pi \times 10^{-7})(0.35)/(2)(0.0725) = .000607$ T
$\mathscr{E} = N_p A_p \Delta B/\Delta t = (1100)(1.26 \times 10^{-3})(0.000607)(200) = 168$ mV

Measured: 180 mV

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